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Could Curcumin hydrogel for photodynamic therapy fight against SARS-CoV-2?

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Abstract: A traditional Chinese medicine "Curcumin" has been used as a photosensitizer in the application of photodynamic therapy such a long time. However, it has significant limitations, including poor "solubility" and "absorbtivity". "Hydrogel" is being used to overcome these problems, which enhance the biodegradability and biocompatibility of curcumin. This present article discusses the background, research progress, and clinical study to describe the possibility of curcumin hydrogel for photodynamic therapy fight against SARS-CoV-2. Based on the literature review finding, curcumin as a photosensitizer uses a microcatheter to incorporate the hydrogel systemically or locally into the lungs through the pulmonary artery to combat SARS-CoV-2. It is extracorporeal illumination for photodynamic therapy, which exposure to blue light with a mean wavelength of 450 nm is a much safe and limited depth of photodynamic therapy treatment. Thus, curcumin incorporated with the hydrogel is a suitable candidate used for the photodynamic treatment of SARS-CoV-2, cancer, wound healing, and bacterial infection.

Keywords: curcumin; hydrogel; photodynamic therapy; SARS-CoV-2.

1. Introduction

Curcumin is traditional Chinese medicine and has been used as a photosensitizer (PS) in photodynamic therapy (PDT) for a long time ago. It is natural and non-toxic PS. When curcumin activates by blue light, which absorbs a suitable wavelength between 300 and 500 nm, it produces reactive oxygen species (ROS), singlet state oxygen, hydrogen peroxide, and hydroxyl radicals during the PDT process [1,2]. The previous article discussed photodynamic therapy with curcumin for combating SARS-CoV-2 [3]. Still, there are some significant limitations for curcumin to be a PS, such as "solubility" and "absorptivity" [4] that affect the PDT efficacy, so how do we improve these issues? "Hydrogel" is a three-dimensional (3D) structure with a large amount of water content containing natural polymers and their derivatives or mixtures. The natural polymers include polyamides [5], poly (ethylene oxide) [6], polyacrylic acid derivates [7], gelatin [8]. It can serve as a carrier and release system for PS to enhance its biodegradability and biocompatibility for PDT [9-14].

2. Research Process

Growing evidence has shown that hydrogel combines with PS in PDT to increase the range of applications, e.g., cancer, wound healing, and bacterial infection treatment [15]. Leung B *et al*. reported the hydrogel containing methylene blue for topical antimicrobial photodynamic therapy. Methylene blue is another natural herbal PS similar to curcumin. This is promoted the bacterial killing efficiency of antimicrobial photodynamic therapy (PDT), which is mediated by methylene blue (MB) incorporated with hydrogels against methicillin-resistant Staphylococcus aureus (MRSA). The effective rate is more than three times [16]. Glass S *et al*. discovered the uptake and release of the following photosensitizers as 5,10,15,20-tetrakis(1-methyl-4-pyridinio)porphyrin tetra(p-toluene-sulfonate) and sodium meso-tetraphenylporphine-4,4′,4″,4‴-tetrasulfonat, eosin. Methylene blue is possible to load the hydrogels in the μmol g^{-1} range. These are highly active and produce sufficient singlet oxygen to enhance the PDT efficiency and its applications [17]. Freitas CFD *et al*. identified curcumin and silver nanoparticles carried out from polysaccharide-based hydrogels improved the photodynamic properties of curcumin. It combines with silver nanoparticles (AgNPs) and visible light by PDT through the MEO effect (Metal-Enhanced Singlet Oxygen), which leads to cell death or apoptosis. Hydrogel concentration is around 91.5 μg mL^{-1}, not toxic to the healthy cells, and PDT selectively suppresses the Caco-2 human colon cancer cells by the Chitosan/chondroitin sulfate/CUR-AgNPs [18].

Kipshidze N *et al*. reported the pathogenesis of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in COVID-19 induced acute respiratory distress syndrome (ARDS). The SARS-CoV-2 binds to the heme groups in hemoglobin, leading to severe hypoxia. Heme is composed of a ring-like organic compound known as porphyrin and SARS-CoV-2 attached to the heme groups, causing lung failure because of deoxygenated blood [19]. Therefore, in traditional chinese medicine, "Curcumin" as a PS uses a microcatheter to incorporate the hydrogel systemically or locally into the lungs through the pulmonary artery to combat SARS-CoV-2. Hence, a strategy of curcumin hydrogel for photodynamic therapy fight against SARS-CoV-2 is proposed (Fig. 1). Curcumin loads the hydrogel and inhibits or kills the SARS-CoV-2 through a suitable light activation in PDT.

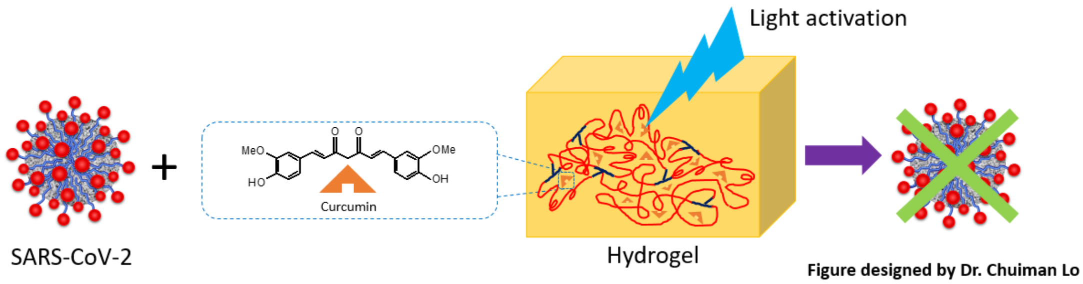

Figure 1. Curcumin hydrogel for photodynamic therapy fight against SARS-CoV-2.

3. Clinical Study

In the clinical application, we suppose the curcumin hydrogel is extracorporeal illumination for photodynamic therapy, which exposure to blue light with a mean wavelength of 450 nm. The great benefit of extracorporeal for the patient is a much safe and limited depth of PDT treatment. Light at a wavelength of 450 nm can penetrate only 0.2 to 2 centimeters into the epidermis without causing damage to normal tissue. It is also no harm to the host immune system. Curcumin hydrogen has a specific wavelength and selectively kills viruses with minor wear to normal tissue. Furthermore, the reactive distance of singlet oxygen is short (only 20 nm), and the duration is short (40 sec); the cytotoxic effects are limited to the area in which the ROS is produced. In 2017, Geralde MC *et al*. reported pneumonia treatment by photodynamic therapy with extracorporeal illumination already [20].

4. Conclusion

The above information demonstrates that the hydrogel is a three-dimensional (3D) structure with a large amount of water content to improve or enhance curcumin biodegradability and biocompatibility for PDT efficacy. Curcumin incorporated with the hydrogel is typically used for cancer, wound healing, and bacterial infection treatment; therefore, it is also a possible candidate for combating SARS-CoV-2. However, more works need to be done, such as dosage and safety assessment in the human body.

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Conflicts of Interest

The authors declare no conflict of interest.

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